Processing effects on the chemical composition and nutritional potential of the pigeon pea (Cajanus cajan L.)

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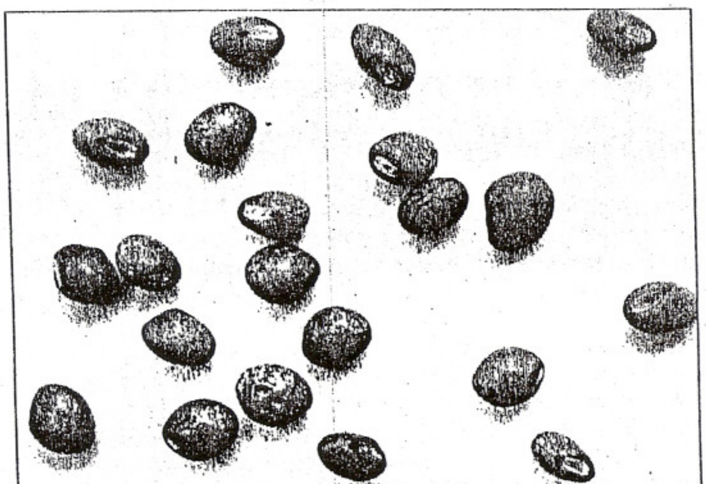
The effects of processing on the chemical composition and nutritional potential of the seeds of *Cajanus cajan* have been estimated. Raw, soaked, cooked, and autoclaved seeds were analysed for proximate composition, calcium, magnesium, phosphorus, manganese, iron, copper, structural carbohydrates, nutritive and non-nutritive matter and certain antinutritional factors (phytic acid, total oxalate, tannins, total phenolics and trypsin inhibitor activity). The results indicated that the caloric value of the seeds was improved by soaking, cooking and autoclaving, and that cooking and autoclaving significantly lowered the levels of antinutritional factors in the seeds.
Key words: pigeon pea, processing method, chemical composition, antinutritional factors

INFLUENZA DEL PROCESSO SULLA COMPOSIZIONE CHIMICA ED IL POTENZIALE NUTRIZIONALE DI CAJANUS CAJAN L.

E stata studiata l'influenza del processo di lavorazione sulla composizione chimica ed il potenziale nutrizionale dei semi di Cajanus cajan. Semi grezzi, lasciati in ammollo, cotti e trattati in autoclave sono stati esaminati per studiarne la composizione chimica, il contenuto in calcio, magnesio, fosforo, manganese, ferro, rame, carboidrati, sostanze nutritive ed anti-nutrizionali ed alcuni fattori come acido fitico, ossalati totali, tannini, fenoli ed attività anti-tripsinica. I risultati indicano che il valore calorico migliora per i semi immersi in acqua, cotti ed autoclavati e che la cottura e il passaggio in autoclave abbassa in modo significativo il livello dei fattori anti-nutrizionali.
Parole chiave: *Cajan cajanus, metodi di trattamento, composizione chimica, fattori anti-nutrizionali*

INTRODUZIONE

A gap exists between the population growth and protein supply in Nigeria, where pro capite income is low and majority consume less protein than the recommended daily allowance. A concern of nutritionists in the country therefore is to find alternative source of protein. Food legumes such as *Vigna unguiculata* and *Glycine max.* have been targeted in the campaign for increased consumption. However, yet unexploited is the utility of the seeds of *Cajanus cajan*, a legume whose cultivation is well supported by soil and prevailing climatic conditions of the western region of Nigeria. Indeed, in the geographical zone of the country, the seeds are boiled and eaten by the natives [11].



Cajanus cajan L. seeds

The purpose of this study was to determine the chemical composition and to evaluate the nutritional potential of the seeds of *Cajanus cajan* as affected by processing methods.

MATERIALS AND METHODS

Sample collection and preparation

The seeds of *Cajanus cajan* L. cv IITA 8860 were collected from the International Institute of Tropical Agriculture, Ibadan, Nigeria and were processed as follows:

- *Soaking* – Dry seeds were soaked at room temperature in deionised water for 48 hs. Soaking water was changed every 6 hs, and at the end of the soaking period the seeds were drained of excess water and freeze-dried.
- *Cooking* – The cooking procedure of Manan et al. [14] was adopted. The seeds were steeped in excess deionised water for 4 hs at room temperature. After inhibition, the excess was drained off. An additional quantity of deionised water was added to the steeped seeds and the mixture was boiled for 40 min. After cooking, the excess water was removed and the cooked seeds were freeze-dried.
- *Autoclaving* – The dry seeds were milled, autoclaved for 20 min at 10.400 kgm^{-2} and then freeze-dried.

Freeze-dried samples of raw, soaked, cooked, germinated and autoclaved seeds were ground separately to pass through a 40 mash sieve in preparation for subsequent chemical analyses.

Analytical procedure

Samples of raw and of the differently processed seeds

Table I – Proximate and mineral composition of *Cajanus cajan* as affected by processing methods*

	Processing method				
Component	Raw	Soaking	Cooking	Autoclaving	±SEM⁺
Proximate composition					
Crude protein, %	21.85	21.32	21.69	21.01	0.189
Fat, %	2,70	2.28	2.23	2.42	0.105
Crude fibre, %	8.30	7.85	7.25	7.85	0.215
Ash, %	4.60	3.20	3.40	4.15	0.326
Nitrogen free extractives, %	62.55	65.35	65.43	64.57	0.670
Energy, Kcal/100 g	361.90b**	367.20a	368.55a	364.10a	1.503
Mineral composition					
Calcium, mg/100 g	140.00	127.00b	118.20c	138.65a	5.159
Magnesium, mg/100 g	88.86a	79.62b	66.98c	87.26a	4.992
Phosphorus, mg/100 g	290.00a	268.75b	251.10c	288.38a	9.190
Manganese, mg/100 g	2.94	2.92	2.54	2.87	0.094
Iron, mg/100 g	5.52	5.16	5.32	5.30	0.074
Copper, mg/100 g	1.06	1.05	0.99	1.03	0.015

(*) Values are on dry matter (DM) basis; ⁺SEM, standard error of the mean; (**) Mean values in a row denoted by different subscripts differ significantly at P≤0.05

Table II – Structural carbohydrates and nutritive and non-nutritive fractions of *Cajanus cajan* as affected by processing methods*

	Processing method				
Component	Raw	Soaking	Cooking	Autoclaving	±SEM⁺
Structural carbohydrates					
Cell wall carbohydrates, %	8.76	7.90	7.46	8.05	0.270
Cellulose, %	4.23	4.37	4.41	4.33	0.039
Hemicellulose, %	4.53	3.53	3.05	3.72	0.308
Nutritive components					
Cellular content, %	91.70	92.15	92.75	92.15	0.215
Organic cellular content, %	87.65b**	89.05a	89.45a	88.35ab	0.397
Soluble ash, %	4.05a	3.10b	3.30b	3.80ab	0.219
Soluble carbohydrate, %	67.15b	68.55a	68.83a	68.72a	0.392
Non-nutritive components					
Acid-insoluble ash, %	0.55	0.10	0.10	0.35	0.109
Lignin, %	1.50	2.05	2.10	1.75	0.140
Non-nutritive matter, %	2.05	2.15	2.20	2.10	0.032

(*) Values are on DM basis; ⁺SEM, standard error of the mean; (**) Mean values in a row denoted by different subscripts differ significantly at P≤0.05

were analysed for proximate composition [1]. The crude protein content was calculated by multiplying the per cent Kjeldahl nitrogen by the factor 6.25. Total ash was fractionated into acid soluble ash (SA) and insoluble ash (AIA) as described by Egan et al. [6]. The energy content was determined by multiplying the percentages of crude protein, crude fat and nitrogen free extractives by the factors 4, 9, 4, respectively [17].

Calcium, magnesium, manganese, iron and copper contents were analysed by atomic absorption spectrophotometric method [18]. Phosphorus content was determined colorimetrically using phosphovanado molybdate method of AOCA [1].

Cell wall carbohydrate (CWC), cellulose, hemicellulose, cellular content (CC), organic cellular content (OCC), soluble carbohydrate (SC), non-nutritive matter (NNM), and lignin contents of all samples were determined by the procedures of Fonnesbeck [7]. Digestible energy values of samples for different laboratory animals were estimated by fitting data from chemical analyses into the prediction equations described by Fonnesbeck [7].

Antinutritional factors such as phytic acid [22] total oxalate [12], tannins [4], and total phenolics [21] contents were estimated. Trypsin inhibitor assay was done by the method of Kakade et al. [10].

Statistical analysis

All data were subjected to analysis of variance in accordance with the method of Gomez and Gomez [8]. Signifi-

Table III – Estimated digestible energy (DE) values of raw and differently processed *Cajanus cajan* for different laboratory animals[+]

	DE Kcal/100 g DM obtainable from				
Laboratory animal	Raw	Soaked	Cooked	Autoclaved	±SEM**
Rabbit	313.01	313.12	310.27	315.68	
Rat	393.26	397.85	400.16	398.26	
Swine	398.73	395.72	395.89	400.09	
Mean	*368.33b**	*368.90ab*	*368.77ab*	*371.34a*	*±0.679***

(+) Prediction equations of Fonnesbeck [7] used for DE estimation are:

Rabbit: DE=4.67 - 0.231 NNM (%) - 0.0456 CP (%) R^2 0.971 ; $S_{y.x}$, 0.101

Rat : DE=2.54 - 0.0272 CF (%) + 0.0241 SC (%) R^2 0.973 ; $S_{y.x}$, 0.094

Swine : DE=2.22 + 0.0292 SC (%) – 0.129 lignin (%) R^2 0.983 ; $S_{y.x}$, 0.073

(*) Mean values in a row denoted by different subscripts differ significantly at P≤0.05;

(**) SEM, standard error of the mean

Table IV – Antinutritional factors in *Cajanus cajan* as affected by processing method

	Processing method				
Component	Raw	Soaking	Cooking	Autoclaving	±SEM*
Phytic acid, mg/100 g	810.50a**	126.68b	132.52b	127.02b	170.445
Total oxalate, %	15.40a	4.15b	5.42b	5.36b	2.622
Tannins, mg/100 g	2.23a	0.42c	0.96b	1.02b	0.382
Total phenolics, μg/100 g	22.75a	24.05a	4.25b	3.79b	5.602
Trypsin inhibitory activity[+]	15.42a	16.86a	0.00b	0.00b	4.668

(*) SEM, standard error of the mean; (**) mean values in a row denoted by different subscripts differ significantly at P≤0.05; (+) expressed as units of enzyme activity inhibited per mg protein

ntly different treatment means were separated by the ethod of Duncan [5].

ESULTS AND DISCUSSION

Table I shows the proximate and mineral composition the seeds of *Cajanus cajan*. Compared to the seeds of idely consumed *Vigna unguiculata* in Nigeria, the results vealed that the seeds of *Cajanus cajan* contained lower tal crude carbohydrate (NFE) but they had higher crude bre contents. However, seeds of both legumes were siilar in crude protein, fat and ash contents. With the exeption of their higher crude fibre content, the seeds of *ajanus cajan* were closer to the seeds of *Phaseolus luatus* in proximate composition [16]. The caloric value of *ajanus cajan* was about the same with the food energy alues of *Vigna unguiculata, Phaseolus vulgaris, Phaseolus limensis, Pisum sativum* and *Lens culineris* [15].

With the exception of calcium, the seeds of *Cajanus cajan* were superior to those of *Abrus precatorius* [19] in their contents of the mineral elements determined in this study. *Cajanus cajan* seeds were richer in their mineral composition than the seeds of *Vigna unguiculata, Phaseolus vulgaris, Lens culineris* and *Pisum sativum* [11].

Experimental treatments significantly affected the caloric value, calcium, magnesium and phosphorus contents of the seeds of *Cajanus cajan* (Table I). Caloric value increased with soaking, cooking and autoclaving. Ca, Mg and P contents were reduced with soaking and cooking, but were unaffected by autoclaving.

Estimation of the total caloric value of foods by the methods of Osborne and Voogt [17] was based on energy contributed by protein, fat and carbohydrate. Crude fibre (or CWC) was not considered on the assumption that it was indigestible by human digestive enzymes [20]. On the contrary, Fonnesbeck [7] confirmed partial utilization of CWC and declared lignin as the indigestible component of the CWC. Together with AIA, lignin constituted the non-nutritive matter of the food. Furthermore, Fonnesbeck [7] established regression equations describing the relationship between nutritive and non-nutritive components of foods and digestible energy (DE) values of such foods for different species of animals.

Consequently, structural carbohydrates, nutritive and non-nutritive fractions and estimated DE values of raw and differently processed seeds of *Cajanus cajan* were determined and the results are shown in Tables II and III. While OCC increased marginally in autoclaved seeds, significant increases were found in cooked seeds, whereas a marginal reduction was noted in autoclaved seeds. All the processing methods markedly increased the SC contents of the seeds. DE values increased marginally in soaked and cooked seeds, but increased significantly in autoclaved ones.

Like the aforementioned legumes, the seeds of *Cajanus cajan* contain antinutritional factors such as phytic acid, oxalate, tannins, phenolics and trypsin inhibitor (Table IV) all of which have been reported to limit the utilisation of the legumes by interfering with the digestion, absorption and metabolism of the valuable nutrients they contain [13]. Attempts have been made with remarkable success to improve availability of nutrients in the legume seeds by soaking and heat treatment [9, 16, 3, 14, 2].

The effect of processing on the phytic acid, total oxalate, tannins, total phenolics and trypsin inhibitory activity in the seeds of *Cajanus cajan* is shown in Table IV. Phytic acid, total oxalate and tannin contents were significantly reduced by all the processing methods. Levels of total phenolics and trypsin inhibitory activity were not significantly affected by soaking but were decreased by the heat treatments (cooking and autoclaving).

Based on data from this study, the autoclaved seeds of *Cajanus cajan* may constitute an addition to the list of food legumes being advocated for consumption in Nigeria.

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